

CHLOROFORM

A Manual

FOR STUDENTS AND PRACTITIONERS.

EDWARD LAWRIE,

M.B. Edin.; M.R.C.S. Eng.;

Lieutenant-Colonel I.M.S.; Residency Surgeon Hyderabad;

Principal of the Hyderabad Medical School

and Lecturer on Surgery;

Surgeon-Superintendent of the Afzulgunj Hospital.

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Dedicated
TO
HIS HIGHNESS THE NIZAM. •

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CHLOROFORM.

INTRODUCTORY.

UP to the year 1889 the opinions on chloroform throughout the medical profession in Great Britain were influenced by two curiously similar factors. In the operating theatre deaths had taken place under chloroform, generally during trivial operations, though Syme and his followers, who entirely disregarded the pulse when chloroform was given, had few accidents and hardly any fatalities. Some of the fatal accidents occurred so rapidly that they were regarded as sudden deaths, and held to be inexplicable on any ground but that of direct failure of the heart. The experimental results obtained by

various observers were no less contradictory. Wakley and others had found that when animals were poisoned with chloroform the respiration stopped before the heart; but the Committee of 1864 of the Royal Medical and Chirurgical Society, who first employed scientific instruments in the investigation, arrived at the conclusion that chloroform is dangerous to the heart and weakens it. This was however merely an inference from their discovery that it lowers the blood pressure. In 1879 the Committee of the British Medical Association concluded that direct paralysis of the heart is produced by chloroform, and that it may sometimes be sudden and capricious, because, as they discovered, the fall of the blood pressure under chloroform is sometimes sudden and apparently capricious.

This was the state of the physiological side of the chloroform question in 1889, when the Hyderabad Commission was appointed for the purpose of deciding whether chloroform does or does not affect the heart directly. "Two Commissions to examine

into the alleged dangers of chloroform have been appointed by His Highness the Nizam's Government. The first Commission, which was appointed in 1888, was applied for by Surgeon-Major E. Lawrie, Residency Surgeon, Hyderabad, because, having always believed in the truth of Syme's teaching that chloroform can be used judiciously so as to do good without the risk of evil, he desired to show by experiments upon dogs that in death from chloroform the respiration always stops before the heart. This point having been proved, the second Commission (since known as the Hyderabad Commission) was applied for, because it was felt that Syme's principles, which both experience and experiment had shown to be practically sound, must be founded upon a firm physiological basis."* The Commission was composed of myself (out of courtesy to the Nizam's Government) as President, and Drs. Lauder Brunton, Bomford, I.M.S., and Rustomji, as members, with a working committee of assistants.

NAWAB SALAR JUNG BAHADUR.

* Report of the Hyderabad Chloroform Commission, page 1.

Writing of the constitution of the Commission, the *Lancet* of September the 21st, 1889, stated :—

“ Dr. Lauder Brunton has not only devoted much time to pharmacological work for more than twenty years, but the fact that his large work on ‘ Pharmacology and Therapeutics,’ which appears also as an American edition, has been translated into French, and is now being translated into German, Italian and Spanish, shows that he is regarded as an authority in other countries as well as our own. It may perhaps be considered as a further advantage that in this work Dr. Lauder Brunton has very decidedly stated that one of the dangers of chloroform is death by stoppage of the heart. ‘ *Audi alteram partem* ’ is the motto of an important section of the *Lancet*, and we think that by getting both opinions regarding the effect of chloroform on the heart represented on the Commission, as they will be by Dr. Lauder Brunton and Surgeon-Major Lawrie, we are more likely to obtain a correct conclusion. The question whether chloroform paralyses the

heart or not is one of the greatest possible practical importance, for upon its correct solution the lives of thousands of people and the happiness of thousands of families may depend. Both in Europe and America clinical experience and physiological experiment have led to the conclusion that it has a paralysing action on the heart. It is almost impossible to believe that the conclusion at which European and American scientists and surgeons have arrived is, after all, destitute of foundation, and little better than an idle dream."

So widespread was the belief that chloroform directly affects the heart, that deaths from chloroform—which had become numerous in exact proportion as that belief had gained ground—were reported by the medical journals week after week as due to primary or secondary heart failure, and the terms "primary," and "secondary," "chloroform syncope" constituted the established nomenclature of accidents under chloroform.

The quotation from the *Lancet* is given here

to show the importance which was attached to the solution of the chloroform question. Next to the saving of life, the prevention and relief of pain are the most important functions of the physician, and it is acknowledged that anæsthesia ranks, with anti-sepsis, as one of the two main factors in the advance of the science and art of medicine during the last thirty years. I can speak freely of the experiments of the Hyderabad Commission, because I took no actual part in them. They were performed entirely under the direction of Dr., now Sir Lauder, Brunton, and every fact was noted by Dr. Bomford as it occurred. I have seen experiments performed by leading physiologists since the days of the Hyderabad Commission, but none with more skill and scientific accuracy than those of Sir Lauder Brunton, and no more complete record of facts has ever been collected than those amassed by Dr. Bomford.

The Commission proved that the normal fall of the blood pressure produced by chloroform is harm-

less, and cannot therefore be produced by weakening of the heart. Chloroform produces an after-effect which is dangerous if it is given during struggling and irregular breathing, but it can be used with perfect safety as an anæsthetic, provided, as was long ago pointed out by Syme, that the breathing is properly looked after; and death can only take place from overdosing. Dr. Lauder Brunton proceeded to England to convert Europe and America, but he could not entirely divest himself of the opinion he had held and taught for so many years that "one of the dangers of chloroform is death by stoppage of the heart," and the conversion of Europe and America devolved to a large extent upon me. This was an unlooked-for calamity, its sole advantage being that having been engaged ever since the session of the Commission in the daily administration of chloroform at the rate of about two thousand cases a year, I have been enabled to test by clinical experience the value of the ideas suggested by the discussion to which the Commission gave rise. In the prolonged controversy which ensued, it became

necessary to perform further experiments in order to demonstrate precisely how the fall of the blood pressure which chloroform produces, is brought about.

The further enquiry, which, it was hoped, would finally dispose of the whole question, was entrusted by the Nizam's Government to Drs. Gaskell and Shore, the distinguished Cambridge physiologists, and they devised for the purpose cross-circulation experiments, which had never been employed before in connection with chloroform. The essential condition in these experiments, viz., the maintenance of a cross-circulation, is so difficult to establish as to be almost impossible. It consists in cross-connecting the circulations of two animals, which may be called Nos. 1 and 2, in such a manner that the brain of No. 2 shall be supplied with blood entirely by No. 1. If chloroform is now given to No. 1 it reaches every part of its system, as well as the brain alone of No. 2, so that any effect produced on No. 2 must be through the brain alone, since the chloroform does not go to its heart or anywhere

else but the brain. If it is given to No. 2 it practically goes to its heart alone, since it does not reach its brain. Messrs. Gaskell's and Shore's report was published without any attempt to come to an agreement with us, and it was actually discussed at a meeting of the British Medical Association in England before we saw it. The main conclusion arrived at from six experiments was that the normal fall of the blood pressure under chloroform is entirely due to weakening of the heart. This was in direct antagonism to the verdict of the Commission that as the normal fall of the blood pressure was harmless, it could not be produced by weakening of the heart. Views so divergent as these could not be reconciled, and it therefore became necessary to repeat the cross-circulation experiments in Hyderabad, in order, if possible, to detect the fallacy underlying those performed by Drs. Gaskell and Shore at Cambridge. They were repeated, to the number of fifty-three, under almost insuperable difficulties, in Hyderabad. In all the cases where a cross-circulation was established the

fact was verified by a *post-mortem* examination. Such were the difficulties that in only five of our experiments did the *post-mortem* examination prove beyond doubt that the brain of the fed animal, No. 2, was supplied with blood entirely by No. 1, and received no blood of its own. Typical results of these experiments are given in Diagrams II. and III. of the book ; they were published in the *Lancet* of July the 1st, 1893. Hence it was concluded that when chloroform is sent to the brain alone it produces exactly the same effects as it does when it is inhaled in the ordinary way, and that when it is sent to the heart alone it produces no effect at all. It was consequently obvious that in the Cambridge cross-circulation experiments chloroform must have had access to the animal's brain when it was supposed that it was being sent to the heart alone. The physiology of the ensuing chapters is based upon the assumption of the correctness of these Hyderabad experiments of 1892, and contains nothing new. In fact, the book, as a whole, is not an exposition of any new theory, but merely a re-statement

of an old position in the light of later observations and additional experience. Any difference is to be found rather in the emphasis which is laid upon certain facts which were brought out for the first time during the research of the Hyderabad Commission, such for example as the harmless nature of the vasomötor fall of the blood pressure, the protective action of inhibition of the heart by the vagus nerve, and the danger, under certain conditions, of the after-fall of the blood pressure.

It now only remains to show that the doctrine that chloroform has no direct action on the heart must be considered finally established, as it has not been seriously impugned by any later workers in this field.

In 1894 a meeting of the Royal Medico-Chirurgical Society was held in London, at which Messrs. Gaskell and Shore and I were present, when the position of chloroform was discussed. At that meeting the question resolved itself into which cross-

circulation experiments were correctly performed, those carried out in Cambridge or those in Hyderabad. As was natural in a question involving the accuracy of physiological experimentation, the meeting sided entirely with the Cambridge physiologists. Luckily for us, before the meeting broke up Drs. Gaskell and Shore very courteously intimated that they would repeat the cross-circulation experiment at Cambridge, in my presence, for the purpose of convincing me that they were right and I was wrong. The same result was obtained in this experiment as in those previously performed at Cambridge; but a *post-mortem* examination of the two animals was made at my request, and it was then found that the cross-circulation was not properly established, and that chloroform had had access to the brain when it was thought to be going to the heart alone. Obviously the effects which Drs. Gaskell and Shore had all along been attributing to the heart were produced not through the heart, but, in the usual way, through the brain. Their methods of investigation lacked completeness in one important particular. They set out to prove a hypothesis and

their experiments appeared to show that their view was correct. But they never availed themselves of the simple method of verification of their results by *post-mortem* examination of the animals they experimented on, until it was suggested to them, with the above result. The matter was settled by the following letter from Dr. Gaskell:—

THE UPLANDS, GREAT SHELFORD,

8th July, 1894.

DEAR LAWRIE,

We injected the fed (No. 2) dog yesterday from the aorta, and found that the vertebral was well tied on the left side but that the ligature on the subclavian of the right side proximal to the vertebral, which was the only ligature on that side, was in the right position but was not tight, so that the injection was able to pass both into the vertebral [*i.e.* into the brain] and into the arm on that side. This was the last ligature which Shore tied at the time of establishing the cross-circulation, and I have no doubt but that in the flurry of the moment he did not get down to it properly. I wanted him to leave one of the two carotids for the final ligature but he was sure he could tie the subclavian quite certainly. I have very little doubt but that some blood must have passed along that vertebral. We are making another experiment on Tuesday if you would like to come.

Yours very truly,

(Signed) W. H. GASKELL.

Neither this experiment nor that promised in the letter were published by Drs. Gaskell and Shore, and I was therefore precluded from referring to them. For three years the position of chloroform remained almost in *statu quo*, except that it had leaked out that the Cambridge experiments had failed. The terms "primary," and "secondary," "chloroform syncope," gradually disappeared from the medical journals, and their place was taken in the accounts of accidental deaths from chloroform by the equally erroneous term "asphyxia."

The next discussion on chloroform took place at the meeting of the British Medical Association at Montreal in September, 1897, at which I met Messrs. Gaskell and Shore again. After I had stated my views on chloroform, and had quoted the Hyderabad cross-circulation experiments as the final proof that chloroform has no direct action upon the heart, Messrs. Gaskell and Shore stated that my account was untrue, that they had proved it to be so at the meeting of the Royal Medical and Chirurgical Society

on July the 3rd, 1894, and they challenged me to show that anything had since occurred to invalidate either the correctness of their experiments or of their conclusion. In reply, Dr. Gaskell's letter of *the 8th of July*, 1894, in which the incorrectness of the Cambridge experiments was admitted, was read out to the meeting, and this time the victory—which was decisive and permanent—rested with us.

LAUDER SALAR JUNG BAHADUR.

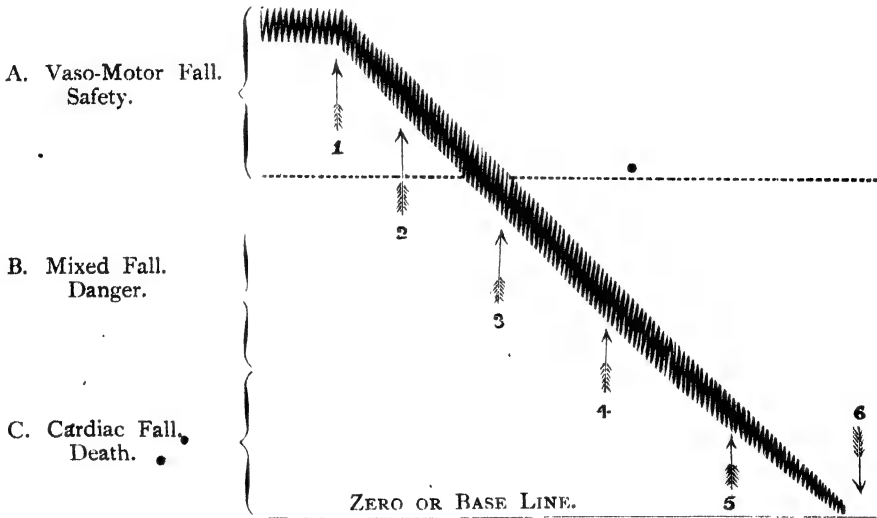
The Hyderabad cross-circulation experiments thus remain as the standard physiological experiments on the subject, and they show beyond all shadow of doubt that chloroform has no direct action on the heart. This important question was thus at length correctly solved. But we who solved it have never obtained any credit for its solution. The physiologists disliked a physician in regular practice, even one so eminent as Sir Lauder Brunton, posing as an authority in experimental science. The position in which I was placed—a mere Indian surgeon with no physiological pretensions, in opposition to two such distinguished physiologists as Drs. Gaskell and Shore,

rendered my opinions of little weight. In Sir Lauder Brunton's own words:—

“The fear of chloroform paralysing the heart is based on laboratory experiments, rather than on clinical experience.”

These words are true, and it is clear that nothing but the laboratory experiments, which we were compelled to perform in self defence, would have finally settled the all-important physiological question of the action of chloroform on the heart.

I.—THE ACTION OF CHLOROFORM.



A. Region of the Vaso-Motor Fall.—Safety.

B. Region of the Mixed Fall.—Danger.

C. Region of the Cardiac Fall.—Death.

Arrow 1. Chloroform commenced.

Arrow 2. Unconsciousness.

Arrow 3. Anæsthesia. The Dotted Line is the Anæsthesia Level.

Arrow 4. Breathing stopped.

Arrow 5. Heart failing.

Arrow 6. Heart Stopped.

PART I.

THE PHYSIOLOGICAL ACTION OF CHLOROFORM.

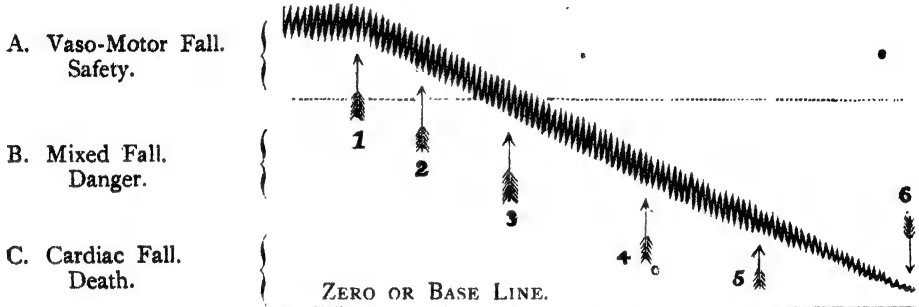
THE action of chloroform is to lower the blood pressure, with first unconsciousness, then anæsthesia, then stoppage of the respiration, and then stoppage of the heart. When given continuously by any means which ensures its free dilution with air, chloroform causes a gradual fall in the mean blood pressure, provided the respiration is not impeded or irregular in any way and continues without struggling or holding the breath. As this fall of the blood pressure proceeds the patient becomes insensible, then the breathing gradually ceases, and lastly the heart stops beating. This action is shown in Diagram No. I. Other things being equal, the more concentrated the chloroform the more rapid the fall, and conversely the greater the degree of dilution the less rapid the fall, until a degree of dilution is reached

which no longer lowers the blood pressure or produces anæsthesia.

The most important point connected with the physiology of the fall of the blood pressure under chloroform is its cause. The Hyderabad Commission was unable to prove more than that a fall of the blood pressure is not in itself dangerous; consequently the fall which is invariably produced by chloroform when effectively given by inhalation cannot be due to failure of the heart. The precise cause was subsequently determined by Professor Gaskell's and Dr. Shore's cross-circulation experiments, by means of which, when a cross-circulation is established between two animals, the chloroform can be sent at will either (*a*) to the heart alone, or (*b*) to the brain alone. When chloroform is sent to the heart alone it produces no effect: it has no direct action on the heart. When it is sent to the brain alone its usual action is exhibited, viz., lowering of the blood pressure, with, first insensibility, then anæsthesia, then stoppage of the respiration, and then

II.—CHLOROFORM TO THE BRAIN ALONE.

(*The Lancet*, JULY 1ST, 1893.)



The Action of Chloroform sent to the Brain alone is identical with its action when inhaled.

A. Region of the Vaso-Motor Fall.—Safety.

B. Region of the Mixed Fall.—Danger.

C. Region of the Cardiac Fall.—Death.

Arrow 1. Chloroform commenced.

Arrow 2. Unconsciousness.

Arrow 3. Anæsthesia. The Dotted Line is the Anæsthesia Level.

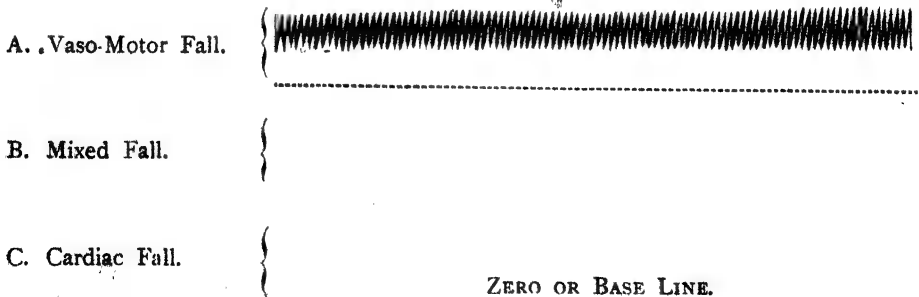
Arrow 4. Breathing stopped.

Arrow 5. Heart failing.

Arrow 6. Heart stopped.

III.—CHLOROFORM TO THE HEART ALONE.

(*The Lancet*, JULY 1ST, 1893.)



Chloroform pushed continuously to Heart alone.

stoppage of the heart. The effect of chloroform when sent to the brain alone, and to the heart alone, is shown in Diagrams II. and III. The action of chloroform is therefore entirely confined to the nerve centres in the brain, and it is clear that it lowers the blood pressure by causing narcosis, first of the vaso-motor and then of the respiratory centre; the fall being due in the first place to dilatation of the smaller arteries, which is harmless, and then, when it is pushed beyond this stage and overdosing takes place, to indirect weakening and failure of the heart, which is lethal.

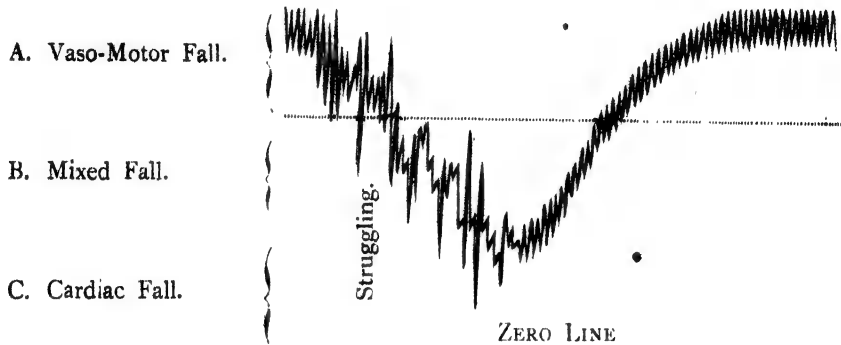
NAWAB SALAR JUNG E

The vaso-motor portion of the fall of the blood pressure under chloroform being entirely free from danger, it is not surprising that if the administration of the anæsthetic is stopped at an early stage the blood pressure very soon begins to rise again to its usual level. But the second part of the fall, that in which weakening of the heart becomes a factor through narcosis of the respiratory centre, is dangerous, and if chloroform is pushed as far as this

stage, there comes a time—not easy to define because of the impossibility in practice of drawing a distinct line between the termination of the vaso-motor and the commencement of the cardiac falls—when the blood pressure and respiration will no longer be restored spontaneously, although the heart may continue to beat after the breathing has stopped.

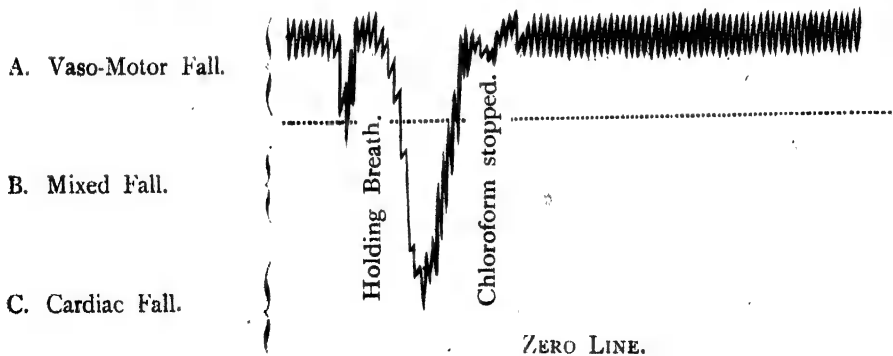
If the inhalation of chloroform is interrupted at any stage, the fall of the blood pressure still continues at a rate which altogether depends on the regularity and rapidity of the fall while the chloroform was being inhaled. This vital and, as will be seen later, all-important after-effect, is called the after-fall of the blood pressure, and is probably due to absorption of a portion of the residue of the chloroform in the system after the stoppage of the inhalation. In this way it often happens, if chloroform is given too freely, that though the respiration may be going on when the chloroform is discontinued, it afterwards stops. It follows, from what has been stated above, that an after-fall of the blood pressure is of little

V.—THE EFFECT OF STRUGGLING ALONE.



This Diagram is taken from Experiment No. 80 of the Hyderabad Commission, Ludwig Reading I.

V.—THE EFFECT OF HOLDING THE BREATH.



This Diagram is taken from Experiment No. 183 of the Hyderabad Commission, Ludwig Reading I.

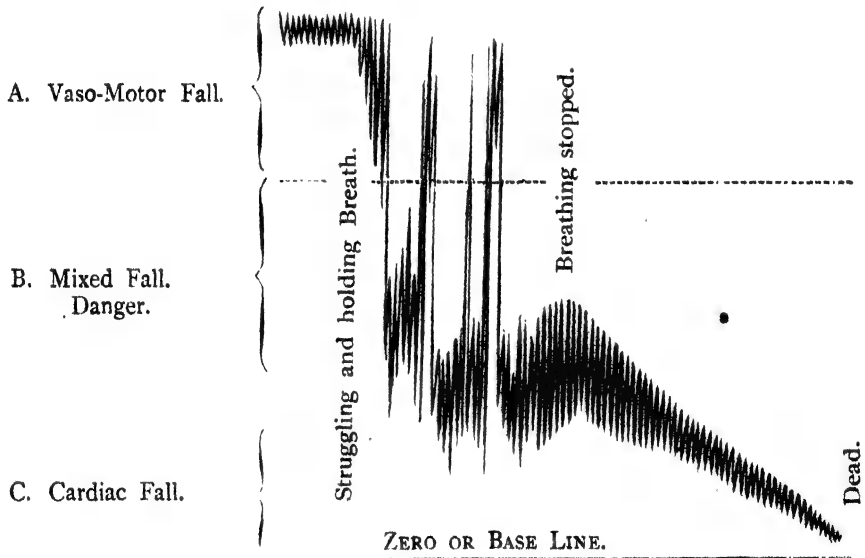
consequence during the early, or vaso-motor, stage of chloroform administration, but that it is excessively dangerous during the later stage, especially if the heart has been weakened by narcosis of the respiratory centre or by asphyxia.

Two conditions disturb the gradual fall of the blood pressure under chloroform, viz., struggling and irregularity of the breathing, especially if the latter takes the form of holding the breath and asphyxia. The effect of struggling alone is to make the blood pressure irregular, and is probably mechanical. It is well shown in Diagram IV. The effect of holding the breath, Diagram V., with more or less asphyxiation is much more remarkable, the blood pressure often falling suddenly to zero, while the heart's action is markedly slowed. As soon as the breath is taken again, the blood pressure rises as suddenly as it fell, and the gasping, or deep respiration, which succeeds causes a large intake of chloroform, which may, in any stage, amount to overdosing, and produce an after-fall of pressure which is highly dangerous. The

sudden falls of the blood pressure which are produced when the breath is held are due to vagus inhibition and consequent stoppage of the heart. They are not in themselves dangerous, but they lead to overdosing in the same way as holding the breath does.

The combination of struggling and holding the breath under chloroform which is shown in Diagram No. VI., causes violent fluctuations of the blood pressure, and then a speedy fall, which very soon leads to dangerous depression from cardiac weakening. The after-effect which is produced is most dangerous, and, whether it occurs in an early or a late stage of the inhalation, it may terminate in rapidly fatal overdosing. Asphyxia, like anything else which leads to, or is accompanied by, deep or exaggerated inspirations, is apt to increase the intake of chloroform beyond normal limits, and bring about a rapid decline of the blood pressure. Even slight asphyxia gives rise to violent oscillations of the blood pressure curve under chloroform, but if the asphyxia is more

VI.—THE EFFECT PRODUCED ON THE ACTION OF CHLOROFORM
BY COMBINED STRUGGLING AND IRREGULAR BREATHING,
HOLDING THE BREATH.



This Diagram is taken from Experiment No. 159 of the Hyderabad Commission
Ludwig Reading I.



decided it produces an effect similar to that caused by holding the breath, or by stimulation of the vagus, and leads to overdosing in the same manner. In addition to this, it is well known that any form of asphyxia under chloroform must weaken the heart, and immensely increase the danger which results from overdosing.

When the breathing stops from an overdose of chloroform, it may or may not begin again spontaneously. It all depends on the character of the after-fall, and how it was brought about. The effect of artificial respiration in restoring natural breathing and blood pressure is usually well marked, but it is never certain that it will be successful, no matter how soon it is commenced after the breathing stops. As in the case of spontaneous restoration, a great deal depends upon the amount and character of the after-fall. Artificial respiration not merely pumps the overdose of chloroform out of the blood, but it exerts considerable influence in exciting the natural breathing. Hence, if the overdose has been slight

and the after-fall moderate, artificial respiration will nearly always be successful in restoring the respiration if it stops. But if the overdose has been excessive, and there has been struggling and holding the breath, or asphyxia, the after-fall may be fatal in spite of artificial respiration.

Drugs do not alter the action of chloroform unless they are given in such doses that their own special effects become predominant. Medicinal doses of morphine, given immediately before or during the administration of chloroform, do not increase the anæsthetic action of the drug, but they produce sleep or rest after the chloroform anæsthesia has passed off.

Chloroform has no power to increase the tendency to shock in surgical operations. Shock and chloroform are incompatibles.

PART II.

THE APPLICATION OF THE PHYSIOLOGY OF CHLOROFORM TO PRACTICE.

1. *The action of chloroform is to lower the blood pressure with, first, unconsciousness, and then anæsthesia.*

The duty of the chloroformist is to produce unconsciousness, or anæsthesia, without lowering the blood pressure at any time during the inhalation beyond the point where anæsthesia is complete. Diagram No. I. shows clearly that if the chloroformist keeps to, and does not exceed, this duty throughout an administration, the region of danger is approached but is never entered.

2. *When given continuously by any means which ensure its free dilution with air, chloroform causes a gradual fall of the mean blood pressure.*

The dilution with air must be sufficiently free to allow the patient, as long as he is conscious, to inhale the chloroform comfortably, and without any sense of suffocation, such as would cause him to struggle or hold his breath ; and at the same time the vapour must be sufficiently strong to lower the blood pressure and produce unconsciousness or anæsthesia. These ends are attained by the use of the Hyderabad cap, and if the patient is particularly sensitive to the pungency of the vapour of chloroform, and cannot breathe comfortably at first, the difficulty can always be overcome by making him blow into the cap after every inspiration.

3. *When chloroform is sent to the heart alone it produces no effect whatsoever : it has no direct action on the heart.*

As chloroform has no direct action upon the heart, it is obviously useless to take the pulse as a guide to its effect. Now that the physiological effects of chloroform are so well known, and it is becoming

recognised that they are the same in the laboratory as they are in the operating theatre, it is almost superfluous to insist that accidents with chloroform must be inevitable unless the pulse is disregarded as a factor in the inhalation. The pulse can only show signs that danger has actually arisen under chloroform, either from overdosing or from interference with the breathing, both of which it is the duty of the chloroformist to prevent. The principles whereby accidents with chloroform can be guarded against with certainty, and overdosing or interference with the breathing prevented, will be fully explained in another section.

4. *If the administration of chloroform is stopped at an early stage the blood pressure very soon begins to rise to its normal level.*

The practical utility of this particular item of the physiology of chloroform is that when the anæsthetic is not pushed beyond the vaso-motor stage of the fall of the blood pressure, it recovers its normal level

almost immediately after the inhalation is stopped. Many operations in surgery can be performed while the patient is in this stage of insensibility, which is far removed from the region of danger, but the recovery is so rapid that only those of short duration can be carried out during the brief period that unconsciousness lasts.

5. *If the inhalation of chloroform is interrupted at any stage, the blood pressure still continues to fall at a rate which depends on the regularity and rapidity of the fall while the chloroform was being inhaled.*

The after-fall of the blood pressure under chloroform, which occurs when the inhalation is interrupted, is practically the most important of all the physiological facts discovered by the Hyderabad Commission. Clinically, it is a contingency which must never for an instant be lost sight of, and, though in the vasomotor stage of the fall of the blood pressure the after-fall is inappreciable if the breathing is not irregular, the only way to avoid accidents with

chloroform is never to disregard the possibility of its occurrence in any stage of the administration.

6. *Two conditions disturb the gradual fall of the blood pressure under chloroform, and lead to overdosing and a dangerous after-fall of the blood pressure—struggling and irregularity of the breathing, especially holding the breath. The combination of struggling and holding the breath causes the most violent fluctuations of the blood pressure.* NAWAB SALAR JUNG BAHADUR.

Struggling disturbs the gradual fall of the blood pressure, and irregularity of the breathing causes irregularity of the intake of chloroform. But struggling and irregular breathing combined, especially holding the breath, lead to overdosing and a rapid after-fall of the blood pressure. They must therefore be treated as signs of the approach of danger, which it rests with the chloroformist to avert. Accordingly, the moment struggling or irregular breathing, with holding the breath, occurs, the chloroform must be stopped, and nothing but air given until all danger

of an after effect has passed off. No doubt holding the breath and reflex stoppage of the heart are in themselves safeguards against overdosing, the former by preventing the chloroform from entering the lungs, and the latter by delaying its conveyance to the nerve centres. But they cannot last long, and even while they do the patient is asphyxiating himself. Deep inspiration and a rapid pulse follow, which cause abnormal intake and rapid conveyance to the nerve centres, and if the chloroform is still over the face there may be an overdose with an after-fall of the blood pressure which may be entirely beyond the control of the chloroformist. In practice, therefore, the rule should never be broken, to regard struggling and irregular respiration as signs of danger which demand the immediate removal of the chloroform inhaler, because it is unsafe to give the anæsthetic while they persist. Experience has shown that, while giving air alone under the conditions above described—even for thirty or forty seconds or more at a time—does not delay the production of anæsthesia, it makes it free from risk.

*7. Morphine produces sleep and rest after the
anæsthesia of chloroform has passed off.*

If the patient is allowed to return to consciousness immediately after severe or painful operations under chloroform, he usually suffers pain for two or three hours. The exhibition of morphine hypodermically, in adults, in a dose of from $\frac{1}{4}$ to $\frac{1}{2}$ a grain, after the first drachm of chloroform has been inhaled, should be the rule in practice. The patient afterwards passes from the chloroform anæsthesia into the seminarcosis of morphine, which lasts until the painful effects of the operation have passed away.

8. Chloroform and shock are incompatibles.

The practical application of this physiological truth lies in the fact that operations can be performed with safety, and without any fear of shock, in any stage of chloroform administration.

PART III.

HOW TO GIVE CHLOROFORM.

Syme's Principles.

To give chloroform with uniform safety it is essential to follow the principles of Syme. In accordance with these principles, the points which are of the greatest importance are : first, a free admixture of air with the vapour of chloroform. Secondly, if this is attended to in such a way that the patient can breathe without any distress or choking, the more rapidly the chloroform is given the better till anæsthesia is produced. Then,—and this is the all-important point—the chloroformist must be guided as to the effect, not by the pulse or by the circulation, but entirely by the respiration ; no one should ever have his finger on the pulse while chloroform is given. If the chloroformist thinks it necessary at any time to examine the pulse in order to find out

how the patient is bearing the inhalation or the operation, the administration should invariably be stopped while the examination of the pulse is being made. No special apparatus is required. The dose can be regulated only by regular normal breathing, which it is the duty of the chloroformist to maintain throughout the administration, whether an apparatus is used or not. Lastly, the anæsthesia should never be pushed beyond the point when the patient is fully under the influence of the anæsthetic.

General Principles.

There is no uniform rule regarding the kind of inhaler to be employed for the administration of chloroform. In Syme's day a folded towel and an unmeasured dose were the fashion, but this plan was clumsy, and expensive on account of wastage. Various kinds of apparatus have been devised, most of them having for their object accuracy of dosage. But it has been pointed out by Captain Clayton Lane, M.D., I.M.S., that we do not want to know the amount of chloroform which is circulating in

the blood. The amount which would overdose a case of empyema would probably not be sufficient to anæsthetise an ordinary case of dislocation of the shoulder. What we want to know in giving chloroform is the precise effect the drug is having on the tissues, *i.e.*, the nerve centres, and no form of apparatus can relieve the chloroformist of the responsibility of always having the effect of the chloroform entirely under his own personal control. The object of a chloroform inhaler should be the free admixture of air with the chloroform, so that the vapour is never so pungent as to interfere with the patient's breathing. As good a form of inhaler as any other is the cloth cone or cap, with a little absorbent cotton stitched into the apex, which is used in Hyderabad. A drachm of chloroform is poured on to the cotton in the cap every three-quarters of a minute or minute, and the cap should be held loosely but closely over the mouth and nose.

The test of unconsciousness under chloroform is the inability of the patient to reply to questions

when spoken to. The tests of anæsthesia are (1) snoring, (2) quiescence and relaxation of the muscles, and (3) abolition of the corneal reflex. Abolition of the corneal reflex is the infallible sign of anæsthesia, but operations can be commenced directly the patient is quiescent, since nothing more is demanded by the surgeon. Snoring is generally the first and most valuable sign of the near approach of anæsthesia. It is usually followed in a few seconds by quiescence, and a little later by abolition of the corneal reflex.

Two or three assistants should always be present when chloroform is given, because in a certain percentage of cases it produces excitement and intoxication, and the patient may struggle so violently as to become unmanageable if assistance is not at hand. No special preparation of the patient is necessary ; the chloroform must be adapted to the patient, not the patient to the chloroform. It is advisable not to permit any solid food to be taken for three or four hours before an operation under chloroform,

since the drug is apt to induce vomiting. But if food has been recently taken, the tendency of chloroform to cause vomiting and indigestion should not debar the surgeon from giving it, and it is better that the food should be vomited than retained in the stomach undigested. If the patient is very weak and nervous, some diffusible or alcoholic stimulant may be given before the administration is commenced, but as a general rule it is wise to do without it ; in fact it is unwise to encourage in any way the idea that the heart requires strengthening or stimulating to enable it to bear the inhalation of chloroform. Everything about the patient's neck, chest, and waist must be loose, and the lower part of the chest ought, if possible, to be exposed, in order that the chloroformist may see the movements of respiration, as well as hear it, all the time the administration is going on.

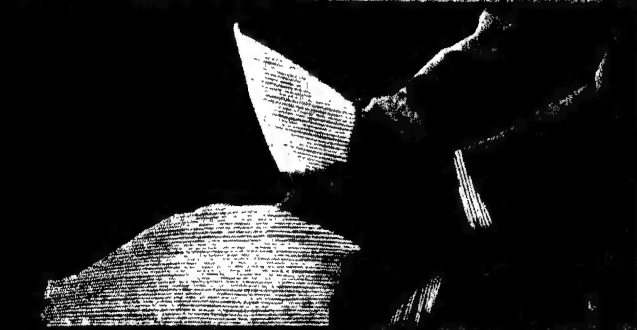
The Administration.

The administration of chloroform should be begun by the application of the cap containing a drachm of

THE WHITE CHRONOMETER
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chloroform gently over the mouth and nose. A great deal depends on the management of this stage of the inhalation. The patient has probably been nervous and excited up to the last minute beforehand, and to make him settle down to inhaling a pungent vapour, which may give him a feeling of suffocation, demands considerable skill on the part of the administrator. If the administration is commenced in such a manner that the patient is able to breathe regularly at first, without any feeling of suffocation and impending death, the whole process will generally be normal and quiet, whereas, if the cap is applied over the face in such a way as to make him resist and choke, and hold his breath, the inhalation will most likely be abnormal and irregular throughout. In placing the cap over the face it is well to cover the mouth in first and then the nose, and it should afterwards be held with the apex pointing as nearly as possible directly upwards, so that the heavy vapour of the chloroform falls almost straight down on to the nose and mouth. The cap should be fairly closely applied, more or less air

being let in from below, but—with the exception of young children—never so tightly as to give the patient or the bystanders the idea that it is being jammed down on to the face.

It is the duty of the chloroformist to ensure normal and regular breathing, and not to allow it to be interfered with in any way while chloroform is given. Adults will generally breathe quietly and regularly into the cap, if they are enjoined to do so, as long as they are conscious. If from any cause they cannot breathe quietly, or if they feel choked, they must be told to blow into the cap after each inspiration. This makes them breathe regularly, and takes away the feeling of choking or suffocation. The only drawback to this plan of ensuring regular breathing is, that as unconsciousness comes on, the patient sometimes blows so rapidly and vigorously that apnoea supervenes. Young children require special management to make them breathe regularly. The way to make a young child breathe regularly is to make it cry, by holding the chloroform cap

close down over its mouth and nose until it becomes unconscious and quiet, when the administration can be proceeded with in the ordinary way. This plan of jamming the cap down over the mouth and nose in young children has no other effect than to ensure regular breathing, by making them cry until they are unconscious. • It does not make them hold their breath and breathe irregularly, as it does adults, and it affords a practical illustration of the physiological fact that in the vaso-motor stage of the fall of the blood pressure, the inhalation of the concentrated vapour of chloroform, even in a very young child, has neither any bad effect, nor has it any after-effect, so long as the breathing is regular.

At the end of each minute, or forty-five seconds, a drachm of chloroform is added to the cap. To do this the cap should be removed from the face, and, before the fresh chloroform is poured into it, the chloroformist should satisfy himself first that the colour of the patient's face is normal and that his breathing is unimpeded, and secondly, by testing the sensibility

of the cornea, that no after-effect is being produced. The fresh drachm should then be poured in, the sensibility of the cornea again be tested, and the cap should only be reapplied when the chloroformist is satisfied that there is no after-effect. There is no hurry about this; it takes from six to eight or ten seconds, or more, during which the patient is breathing nothing but pure air. Every time fresh chloroform is added, the reapplication of the cap to the patient's face by the chloroformist virtually constitutes a certificate that no after-effect is being produced. In the early stages of the administration this is not of much importance, but as the inhalation proceeds and anæsthesia sets in it becomes more and more important, and is one of the two great safeguards against overdosing.

As a general rule unconsciousness supervenes after the inhalation of the second or third drachm of chloroform, and in this stage many of the minor operations of surgery can be performed. Such operations as the insertion of an aspirating needle into a

cavity, the incision of whitlows and abscesses, the breaking-down of adhesions in a stiff joint, and many others which only require a few seconds for their actual performance, can be carried out while the patient is insensible, and though there may be reflex struggling or shouting, he will not remember anything about it afterwards, nor as a rule will there be any vomiting. The two drawbacks to operating in this stage of partial anæsthesia are the occasional struggling which the operation gives rise to, and its short duration. But if the patient becomes boisterous, or the operation has to be prolonged, the chloroform can be continued with the usual precautions until anæsthesia is complete.

Struggling or irregular breathing and holding the breath during the administration of chloroform are signs of danger ahead, which it rests entirely with the chloroformist to avert. The danger is that if the chloroform cap is held over the face while the patient is struggling, breathing irregularly, and

holding his breath and thus asphyxiating himself, an overdose may be taken in and an after-effect produced which may be altogether beyond the chloroformist's control. The instant, therefore, that irregular breathing, struggling, and holding the breath occur under chloroform, it is the duty of the chloroformist to remove the inhaler forthwith, and not to give the patient any more chloroform until the respiration is regular again, the face is a natural colour, and there is no possibility of an after-effect. Struggling, with irregular breathing and holding the breath under chloroform must be regarded by the chloroformist as danger signals. As long as the danger signal is up it is unsafe to give chloroform, and the patient must breathe nothing but pure air; and the signal must not be considered "off" and the inhalation of chloroform proceeded with, until the colour of the face is absolutely normal, and the chloroformist is satisfied that the breathing is regular, and that no after-effect whatsoever is being produced. This is the second of the two great and allied safeguards against accidents with chloroform, and it is

safe to say that if they are not neglected accidental overdosing need never occur.

As anæsthesia approaches, the patient's breathing becomes snoring and regular, and the voluntary muscles become completely relaxed. Very shortly afterwards the sensibility of the cornea to touch disappears, the reflex is abolished, and unconscious winking no longer occurs. The patient is "over." The cap should now be removed, and all that is necessary is to give a little more chloroform from time to time, so as to maintain the anæsthesia at the same level until the operation is finished. The vigilance of the chloroformist must never be relaxed in any way, and the same precautions against overdosing must be persevered with, as long as the operation lasts and the anæsthesia is being maintained, as were found necessary while it was being induced.

If accidental overdosing with chloroform takes place, and the breathing becomes seriously embarrassed

or stops, the lower jaw should be pushed or pulled forwards by the chloroformist and the tongue drawn out with catch forceps. This will generally restore natural breathing. If it does not, artificial respiration should be performed, a few drops of nitrite of amyl being poured on to a handkerchief or cloth and held in front of the patient's nose and mouth while it is continued. The easiest and most effectual way of performing artificial respiration—so as to admit of the other measures being carried on without interruption at the same time—is for the surgeon himself to get on to the operating table, and, kneeling astride the patient, alternately compress and relax the chest and diaphragm. It is a useful plan, for any one who has to teach students how to give chloroform, to hold frequent demonstrations of overdosing in the dog, and exercise them in the needful measures of restoration until they know how to act in similar cases of emergency in man.

Chloroform is frequently employed in midwifery. For midwifery operations it should be administered

in the usual way. When used merely to assuage the pains of labour, it should be given in a ten- or twenty-minim dose in the ordinary cap with each pain, and none should be inhaled in the intervals between the pains. In normal labours, chloroform should, as a rule, only be given in the later part of the second stage—seldom earlier. Begun at this stage, the ten-drop dose at first produces very little effect. As the pains increase in frequency and duration the effect becomes more and more marked, until just at the most painful time, during the expulsion of the head, it will generally be found that the patient is unconscious, and beyond this point the anæsthetic need not be pushed.

In dentistry the anæsthesia of chloroform, whether partial or complete, is infinitely superior to that of gas. Partial anæsthesia is sufficient for most dental operations of brief duration, such as the extraction of one or two teeth, and possesses the decided advantage of freedom from the vomiting and other ill effects which sometimes follow full anæsthesia

with chloroform. For more lengthy operations the superiority of chloroform is even more manifest, as the period of narcosis can be indefinitely prolonged, and the operation can be performed without the slightest hurry, which is never possible with gas. When the case is ready, and it is quite certain that no after-effect is being produced, the chloroformist should push forward the patient's lower jaw and keep it in this position until the operation is finished. This greatly facilitates the opening of the mouth and the use of the gag as well as the extracting of the teeth, and, what is more important, prevents any possibility of obstruction of the breathing during the extraction. There is no doubt that the benefits of anæsthesia would be immensely extended if all dentists were taught how to give chloroform in the Hyderabad methods.

PART IV.

CLINICAL OBSERVATIONS AND NOTES.

Observations.

EVERY event that takes place during the administration of chloroform should be noted on the spot, as it occurs. Such notes have not merely a statistical value, but form data for tracing any accident that may happen to its proper cause. Moreover by taking careful notes the attention of everybody who is present is concentrated on the administration, and, however slight the operation may be, there is no possibility of the inhalation of the chloroform being treated as a trivial matter. It is almost needless to insist that throughout the entire administration, the attention of the chloroformist must never be distracted in any way from the inhalation and its anæsthetic effects, and his responsibility does not cease until the operation is over and the patient shows unmistakable signs of returning consciousness. This rule is

imperative and admits of no relaxation. During the process of administration, there should be no feeling of the pulse, no wiping of the patient's mouth, and no shifting of his position on the operating table, or of the position of the table itself. If any manipulations of this kind are considered necessary the chloroform must be stopped while they are being carried out.

Counting is sometimes depended upon to make the patient breathe regularly during the administration of chloroform. The tendency of counting however is frequently to produce a result which is the opposite of what is intended, as the patient may count from 1 to 20 or 25 without taking a breath, the effect being precisely similar to that of holding the breath, which so often leads to the gasping in of an overdose. Another dangerous practice which has its advocates in some quarters is to keep the patient's lower jaw pulled or pushed well forward for the purpose of warding off stertorous breathing during chloroform inhalation. Paradoxical as it may seem it is nevertheless true that the more successful this measure is

in preventing stertor, the more it conduces to overdosing. Stertorous breathing is a sign of incipient overdosing, in the shape of narcosis of the respiratory centre, and it would be no less unwise to push chloroform with the jaw in such a position that stertor cannot occur, than it would be to push it with the patient's eyes bandaged so that the sensibility of the cornea cannot be tested.

In any case where the condition of the respiratory organs causes weakening of the heart, chloroform should only be given very sparingly or not at all. The surgeon is often compelled to operate instantly for the relief of conditions in which the heart is so weakened that the mere substitution of one or two per cent. of chloroform for the same amount of air in the air inhaled would stop its action. For instance in tracheotomy, when the heart has been weakened by the most deadly suffocation for some hours beforehand, it is quite unjustifiable to give chloroform, except a mere whiff to distract the patient's attention during the first incision. One drop or so in the cap is all that is

admissible. There are other cases again, such for example as empyema, where the breathing is already seriously embarrassed or hampered, in which chloroform ought never to be pushed further than the stage of unconsciousness. In short, in all cases where there is disorder or weakening of the heart from respiratory affections, chloroform can only add to it by still further interfering with the function of respiration, and in these cases not only is this dangerous, but the slightest narcosis of the respiratory centre, such as is indicated by stertor, may constitute fatal overdosing. Consequently if patients with respiratory diseases must be operated upon, the operation should be performed either without chloroform, or in the first stage of unconsciousness, before any narcosis of the respiratory centre is possible, and beyond this stage the administration of the anæsthetic should not be pushed. There are many other conditions in which similar precautions against overdosing must be observed, and in the weakening of the heart which is brought about by chronic alcoholism, and by certain forms of kidney disease, it is of the last importance, if chloroform is

employed at all, to make absolutely certain that no after-effect whatever is being produced at any time while the anæsthetic is being given.

Notes of Cases.

A few cases are given here from the Afzulgunj Hospital note book to illustrate the principles which have been laid down in the previous portion of this work. Cases I. and II. are good examples of the method of ensuring regular breathing, with complete absence of suffocation, in children, by holding the chloroform close to the mouth and nose and making them cry: and the first also shows how rapidly and safely a minor operation may be performed in a child under this method of partial anæsthesia with chloroform. Case III. shows how partial anæsthesia, combined with morphine, can be employed in operations for empyema. Case IV. is one in which there was no struggling, but it illustrates the way in which an examination is made in a leisurely manner without hurry, for after-effects, every time chloroform is added to the cap. It also demonstrates that this plan of

ensuring safety does not retard the production of anæsthesia. Cases IV. and V. show the way morphine is employed in adults. Case V. is one in which the usual struggling occurred, and it illustrates how chloroform is to be entirely withheld as long as struggling and irregular breathing continue, on account of the danger of administering it during the presence of these symptoms.

Case I.—January the 30th, 1900. Partial anæsthesia in a child.

Name, Bismillah Bee, aetat. 4 years, female. Took food last at 8.15 a.m. to-day. Operation, passing lachrymal probe. Chloroformist's name, A. V. Rajagopaul, 4th year student.

Administration commenced at—

H. M. S.

9. 17. 45. Chloroform. Cup held close down over the mouth and nose. Screaming and crying, regular breathing.
9. 18. 10. Quiet, natural breathing.
9. 18. 20. Lachrymal probe passed.
9. 18. 23. Cap removed.
9. 18. 35. Patient carried away.

One drachm of chloroform was employed, the operation lasted 50 seconds, and there was no vomiting.

Case II.—February the 4th, 1900.

Name, Chintoni, aetat. 7 years, male. Food last taken at 8 a.m. to-day. Pulse, 100. Respirations, 30; immediately before the inhalation was commenced. Operation, lateral lithotomy. Chloroformist's name, Narrain Govind, 4th year student.

Administration commenced in 1 drachm doses at:—

H. M. S.

8. 56. 35. Chloroform. Cap held close down over the mouth and nose. Crying and screaming, regular breathing.

8. 57. 25. Quiet.

8. 57. 35. Cap removed. Chloroform added. Respiration regular.

8. 57. 45. No after-effect, cap reapplied.

8. 57. 55. Shouted, then snoring began.

8. 58. 35. Cornea insensitive, over. Chloroform stopped.

9. 3. 20. Operation finished.

9. 4. 0. Consciousness returning.

9. 4. 35. Patient carried away.

Two drachms of chloroform were employed to produce full anæsthesia, the time being two minutes. The chloroform was added to the cap at the rate of one minim per second; two drachms in all were used; the duration of the operation was eight minutes, and there was no vomiting.

Case III.—January the 29th, 1900. Partial anæsthesia in an adult.

Name, Meran Sab, ætat. 35 years, male. Had food last at 7.45 a.m. to-day. Operation, aspiration of empyema. Chloroformist's name, A. V. Rajagopal, 4th year student.

Administration commenced at—

H. M. S.

9. 41. 5. Chloroform. Breathing quiet and natural.

9. 42. 5. Morphine, gr. $\frac{1}{4}$ hypodermically.

9. 42. 15. Aspiration commenced. Cap removed.

9. 45. 55. Aspiration finished (ten ounces of pus withdrawn).

9. 46. 10. Patient walked away.

One drachm of chloroform was used, and gr. $\frac{1}{4}$ of morphine. The patient was unconscious when the aspirating needle was inserted into the pleural cavity, and lay quiet afterwards while the pus was being drawn off and the needle withdrawn.

Case IV.—16th January, 1900.

Name, Sheik Mohidin, ætat. 56 years, male. Food taken last at 8 p.m. yesterday. Pulse 112, and respirations 32 immediately before the administration was commenced. Operation, dilatation of stricture of the urethra. Chloroformist, A. V. Rajagopal, 4th year student.

Administration commenced at—

- | H. | M. | S. | |
|----|-----|-----|--|
| 8. | 33. | 35. | Chloroform. Respiration, blowing rapidly into the cap. |
| 8. | 34. | 30. | Cap removed. Apnoea, lasted for 35 seconds. |
| 8. | 35. | 5. | Quiet breathing recommenced, no after-effect, cap reapplied. |
| 8. | 35. | 30. | Morphine, grain $\frac{1}{4}$ hypodermically. |
| 8. | 35. | 35. | Cap removed. Chloroform added. |

- | H. | M. | S. | |
|----|-----|-----|---|
| 8. | 35. | 42. | No after-effect. Cap reapplied. |
| 8. | 36. | 40. | Cap removed. Chloroform added. |
| 8. | 36. | 55. | No after-effect. Cap reapplied. |
| 8. | 37. | 40. | Cap removed. Chloroform added. |
| 8. | 38. | 5. | No after-effect. Cap reapplied. |
| 8. | 39. | 2. | Cornea insensitive. Over. Chloroform stopped. |
| 8. | 41. | 17. | Chloroform. |
| 8. | 45. | 0. | Chloroform. |
| 8. | 49. | 55. | Consciousness returning. |
| 8. | 52. | 10. | Patient carried away. |

The production of anæsthesia occupied 5 m. 27 s., but for one minute and twenty-two seconds of this the patient was breathing nothing but air, so that he only inhaled chloroform for 4 m. 5 s. while anæsthesia was being produced. Five drachms of chloroform were employed to produce anæsthesia, and seven drachms for the whole operation. The operation lasted 18 m. 35 s., and there was no vomiting.

Case V.—4th December, 1899.

Name, Chundriah, ætat. 31 years, male. Had food last at 8 p.m. yesterday. Pulse 100 and respirations 28 immediately before the inhalation. Operation, incision for liver abscess. Chloroformist, Yusuf Baig, 4th year student.

Administration commenced at—

H. M. S.

9. 15. 45. Chloroform. Respiration natural and quiet.

9. 16. 15. Cap removed. Table turned round.

9. 16. 23. Cap reapplied.

9. 16. 55. Cap removed. Chloroform added.

9. 17. 5. Morphine, gr. $\frac{1}{4}$ hypodermically.

9. 17. 10. Cap reapplied. No after-effect.

9. 17. 30. Struggling. Cap removed. Breathing irregular.

9. 17. 50. Regular breathing. No after-effect.
Cap reapplied.

9. 18. 0. Cap removed. Chloroform added.

9. 18. 25. Cap reapplied. No after-effect.

- H. M. S.
9. 18. 30. Snoring.
9. 19. 20. Cap removed. Chloroform added.
9. 19. 50. Cap reapplied. No after-effect. Quiet.
9. 20. 15. Cornea insensitive. Over. Chloroform stopped.
9. 26. 30. Consciousness returning.
9. 28. 50. Patient carried away.

Four drachms of chloroform were employed to produce anæsthesia in 4 m. 30 s., but during this time the chloroform cap was removed from the face, and the patient breathed nothing but air for 1 m. 38 s. He actually inhaled the anæsthetic for 2 m. 52 s. only. Five drachms of chloroform were used, the operation lasted for 13 m. 5 s., and there was no vomiting.

Case VI.—September 9th, 1900.

Name, Mrs. B., ætat. 27 years. Took food last at 1 o'clock p.m. to-day. Operation, extraction of wisdom tooth. Chloroformist, Dr. Lawrie. Partial anæsthesia.

Chloroform commenced at—

H. M. S.

- 4. 13. 10. p.m.—Respiration regular and quiet.
- 4. 14. 10. „ —Cap removed. Chloroform added.
- 4. 14. 17. „ —Cap re-applied. No after-effect.
- 4. 15. 10. „ —Cap removed. Chloroform added.
- 4. 15. 19. „ —Cap re-applied. No after-effect.
- 4. 16. 5. „ —Unconscious. Cap removed. Tooth extracted.
- 4. 17. 30. „ —Conscious. Operation finished.

This was a private case, and is a fair example of the advantages of partial anæsthesia in tooth extraction. The patient was not put “over,” but was quite unconscious and felt nothing. The operation lasted altogether four minutes and twenty seconds. There was no sickness, and she was so little inconvenienced that she got up and dressed at once and came out to afternoon tea a few minutes afterwards.

Case VII.—February 15th, 1900.

Name, Yelliah, ætat. 43 years, male. Took food last at 9 p.m. yesterday. Operation, forcible extension of stiff (dislocated seven months) elbow joint.

Pulse 88, respirations 24, immediately before the chloroform was given. The administration was commenced in one drachm doses at :—

		H. M. S.	
Period 1.	Chloroform, one minute.	{ 9. 21. 30.	Chloroform. Blowing, and talking.
Period 2.	Air alone, six seconds.	{ 9. 22. 30.	Cap removed. Morphine, gr. $\frac{1}{4}$ hypodermically. Chloroform added to the cap.
Period 3.	Chloroform, eight seconds.	{ 9. 22. 36.	No after-effect. Cap re- applied.
Period 4.	Air alone, forty-two seconds.	9. 22. 44.	Struggling, and holding breath. Cap removed. Got rapidly purple in the face. When the breathing began again there were about three or four respiratory movements to each breath.

		H.	M.	S.	
Period 5.	Chloroform, nineteen seconds.	{	9. 23.	26.	Breathing regularly again: colour of face normal. No after-effect. Cap reapplied.
Period 6.	Air alone, twenty-two seconds.	{	9. 23.	45.	Cap removed. Chloro- form added.
Period 7.	Chloroform, thirty-eight seconds.		9. 24.	7.	No after-effect. Still struggling slightly, but breathing regularly. Cap reapplied.
			(9. 24.	45.	Cap removed. Directly after the cap was taken away snoring began, it was therefore not re- applied at all.
Period 8.	Air alone, twenty-four seconds.	{	9. 24.	57.	Quiet.
			9. 25.	9.	Cornea insensitive. Over.
			9. 27.	33.	Consciousness returning.
			9. 28.	5.	Patient carried away.

This case demonstrates the vital necessity of not giving chloroform while struggling and irregular breathing make it unsafe to do so. It also shows that an after-effect during the vaso-motor stage of the fall of the blood pressure is not dangerous in itself,

but that the anæsthesia was only prevented from going beyond this stage by the precautions which were taken to prevent overdosing. The time occupied to produce full anæsthesia was three minutes and thirty-nine seconds, but during this time the patient inhaled air alone for one minute and thirty-seven seconds. The giving of air, alone, saved the patient from overdosing and did not delay the promotion of anæsthesia. As it was, an after-effect was produced in spite of all our precautions, which resulted in anæsthesia twenty-four seconds after the inhalation was stopped. It demands considerable moral courage on the part of the chloroformist to take away the chloroform the instant struggling and irregular breathing set in, and stand and look on while the patient's breathing becomes regular again. Seconds seem like minutes. But when it is understood that the uniform safety of the patient depends upon it, it is clear that the duty of not giving anything but air as long as combined struggling and irregular respiration continue, is binding and imperative, and a rule to this effect should be made absolute in the profession.

PART V.

EXPERIMENTAL.

A FEW original experiments, chiefly those of the Hyderabad Commission on Chloroform, are detailed in this section in order to illustrate the points raised in the physiological and clinical portions of the work, and also to justify the opinion expressed on page 14, that the effects of chloroform are the same in the laboratory as they are in the operating theatre, *i.e.*, that clinical data correspond with experimental data regarding the action of the anæsthetic. Sir Lauder Brunton has stated that—

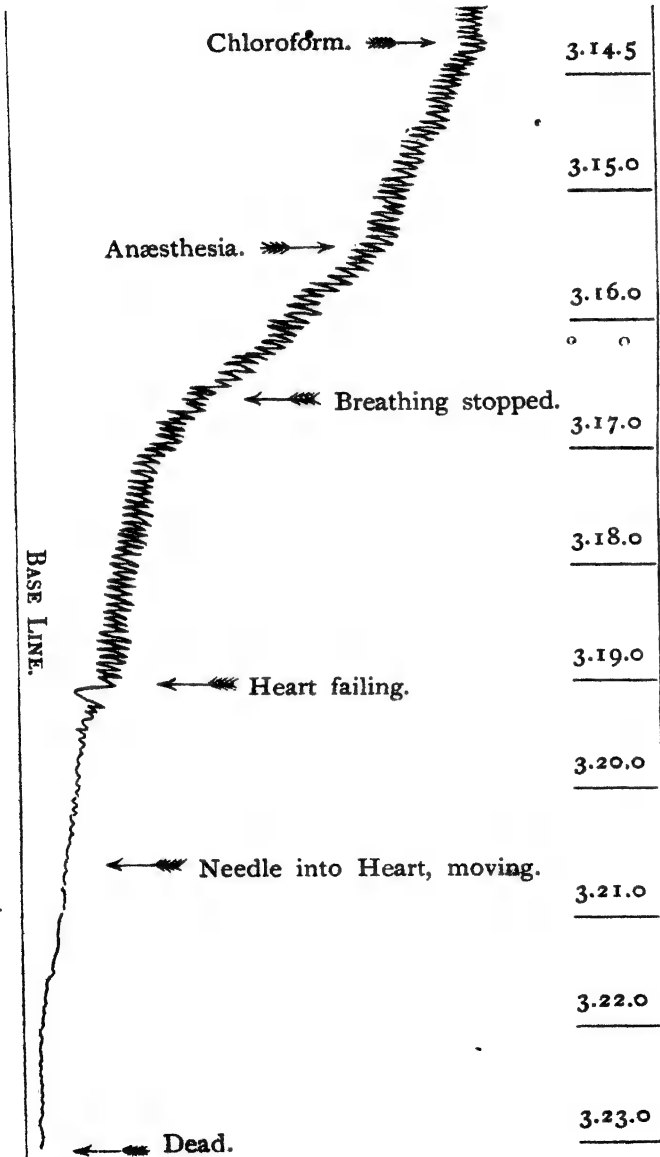
“The objection may be made that the Hyderabad experiments have been made on the lower animals, and, however correct the Commission’s conclusions may be in regard to them, they do not hold for man. To this objection it is a sufficient answer that the fear of chloroform paralysing the heart is based

on the results of laboratory experiments, rather than on clinical experience. * Deaths have occurred during the administration of ether as well as of chloroform, and it is not the deaths during operations, but the observations on blood-pressure and on the action of chloroform on the exposed or excised heart which have led to the unfounded dread in the profession that it may paralyse this organ when given as an anæsthetic."

To this lucid exposition of the case it is only necessary to add that if the Hyderabad research is to be set aside because the Commission's experiments were made on animals, all experiments on animals whatsoever might in like manner be rejected.

The first experiment to consider is No. 186 of the Hyderabad Commission. The tracing shows the effect of the uncomplicated action of chloroform—where the respiration is regular, quiet, and normal throughout—on the blood pressure. There was neither irregularity of the breathing nor struggling, and the fall of the blood pressure was consequently regular

EXPERIMENT No. 186, SHOWING THE UNCOMPLICATED ACTION OF
CHLOROFORM.



and normal. Precisely the same sequence of events occurs in man, up to the point of complete anæsthesia, when chloroform is given with such care that the breathing is not interfered with in any way, and is normal and regular throughout the administration.

March 6th, 1890.—No. 186.

Healthy dog, weight 20 lbs. Temperature of room 28° C. Chloroform given in a box at 1 h. 58 m. 30 s. Dog fallen down at 2 h. 4 m. Dog on table at 2 h. 5 m. Artery ligatured at 2 h. 10 m. 30 s. Canula inserted at 2 h. 12 m. 30 s. Connection with manometer made at 2 h. 16 m. 30 s.

H. M. S.

3. 13. 40.—Ordinary chloroform inhalation uncomplicated by any irregularity of the breathing or struggling, pushed till the animal died. The breathing stopped at 3 h. 15 m. 50 s.; the pulse began to fail at 3 h. 19 m. 25 s.; a needle was inserted into the heart at 3 h. 20 m. 45 s., and continued to move at first strongly and then more and more feebly until it stopped at 3 h. 23 m. 0 s. No recovery took place.

A series of experiments, hitherto unpublished, which deserves careful study, was performed by the late Professor Rutherford in the writer's presence in the physiological laboratory of the Edinburgh University in 1890. He undertook them with his customary courtesy and kindness at the request of Sir Lauder Brunton, mainly in order to determine the effect of vagus inhibition on the action of chloroform. Before the experiments were carried out Professor Rutherford stated his belief that any inhibition of the heart by means of stimulation of the vagus must necessarily weaken it, and this unquestionably voiced the general opinion of the profession at that time. The Edinburgh experiments were performed on the 27th and 28th of May, 1890. Chloroform was administered to rabbits by blowing air saturated with the anæsthetic into the animals' lungs, through a tracheal tube. It was found that if chloroform was administered in this way for more than thirty or forty seconds few recovered, and that a period of ninety seconds was uniformly fatal. Professor Rutherford then determined to retard or arrest the action of the heart by

electrical irritation of the vagus, in order to see if this modified the action of chloroform. In the following experiment the electrode was put on to the nerve, and when it was acting well chloroform was pumped into the lungs.

• • *May 27th, 1890.*

H. M. S.

I. 41. 50. Peripheral end of (divided) left vagus irritated.

I. 42. O. Chloroform.

I. 42 41. Chloroform and stimulation of the vagus stopped. Natural breathing. No effect whatever produced.

After chloroform had been given for 41 seconds, Professor Rutherford stopped the experiment and dictated the following note :—

“The heart had been so much inhibited, that it seemed to be entirely arrested, and the chloroform was stopped after 41 seconds for fear lest the animal should die.”

A photograph of the original notes of this experiment, which were taken by Professor Rutherford's then laboratory assistant, and are now of great historical interest, is reproduced on the next page.

Before the next experiment Professor Rutherford made this note :—

“Having found that 90 seconds of chloroform air would be fatal, we determined to give it for that time in our next observation, and study the effect while stimulating the vagus.”

H. M. S.

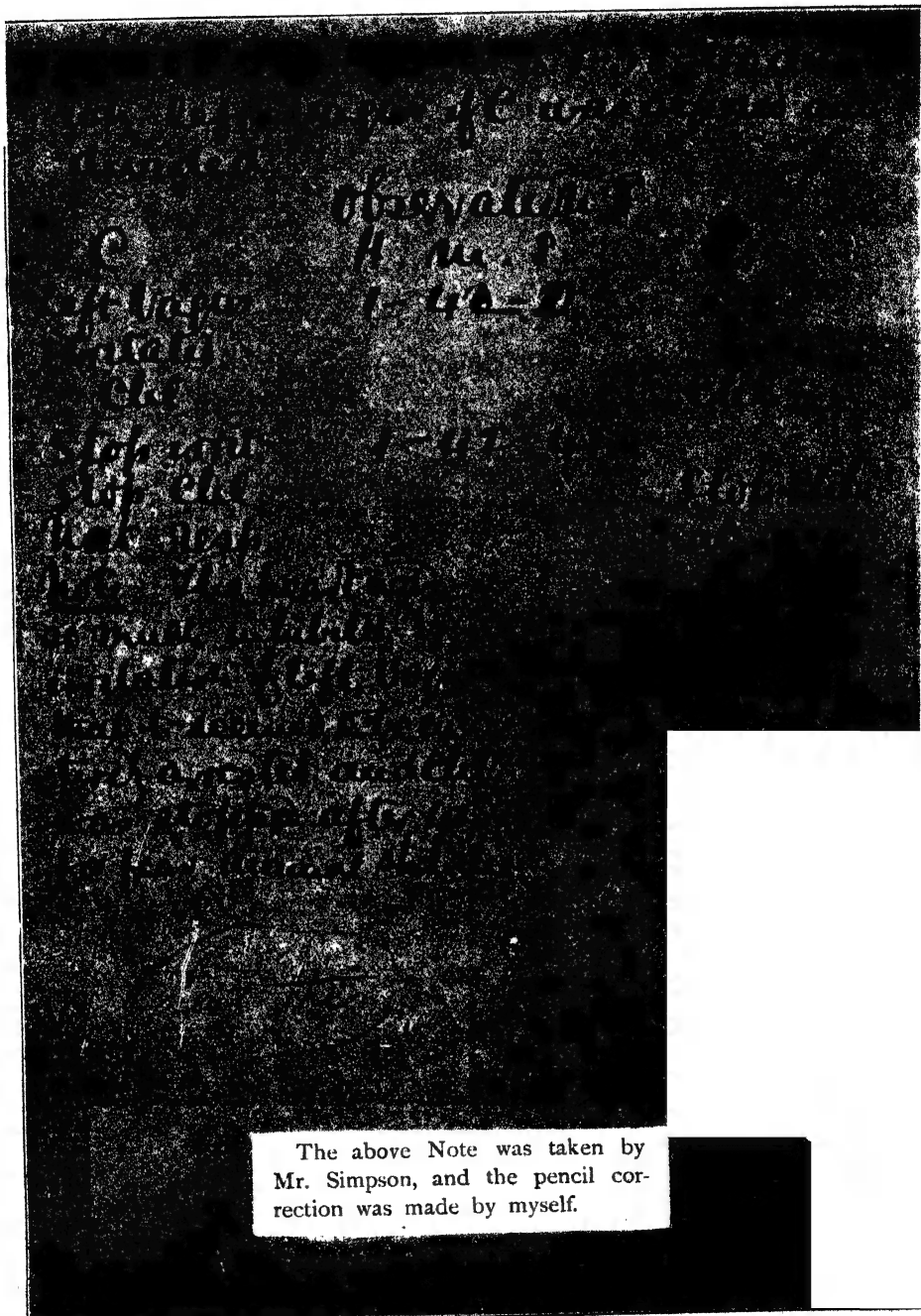
2. 11. 10. Electrode applied. Acting well, and the current increased during the experiment.

2. 11. 15. Chloroform.

2. 12. 45. Chloroform stopped. Breathing naturally immediately, heart beating vigorously.

Professor Rutherford's interesting note on this observation was :—

“This was a dose expected to be fatal.”



Before the next experiment the following note was made by Dr. Rutherford :— .

“In the preceding observation it seemed as if the retardation of the heart had saved the medulla from the serious effect of chloroform. We therefore determined to repeat the chloroformization for the same period, and to omit the stimulation of the vagus in order to see whether under these conditions paralysis of the respiratory centre would be produced.”

H. M. S.

2. 26. 0. Chloroform.

2. 27. 3. Stop chloroform, no breathing, heart very feeble.

2. 27. 30. Artificial respiration.

2. 30. 0. Heart stopped, dead.

The result of these experiments was to establish the safeguard action of the vagus. No effect was produced by chloroform given to a rabbit for 90 seconds while the vagus was stimulated, whereas the same animal died in 63 seconds when the stimulation of the vagus was omitted. Dr. Rutherford's experiments finally negatived the doctrine of the Glasgow

Committee that vagus inhibition is dangerous and can cause sudden death under chloroform by stoppage of the heart.

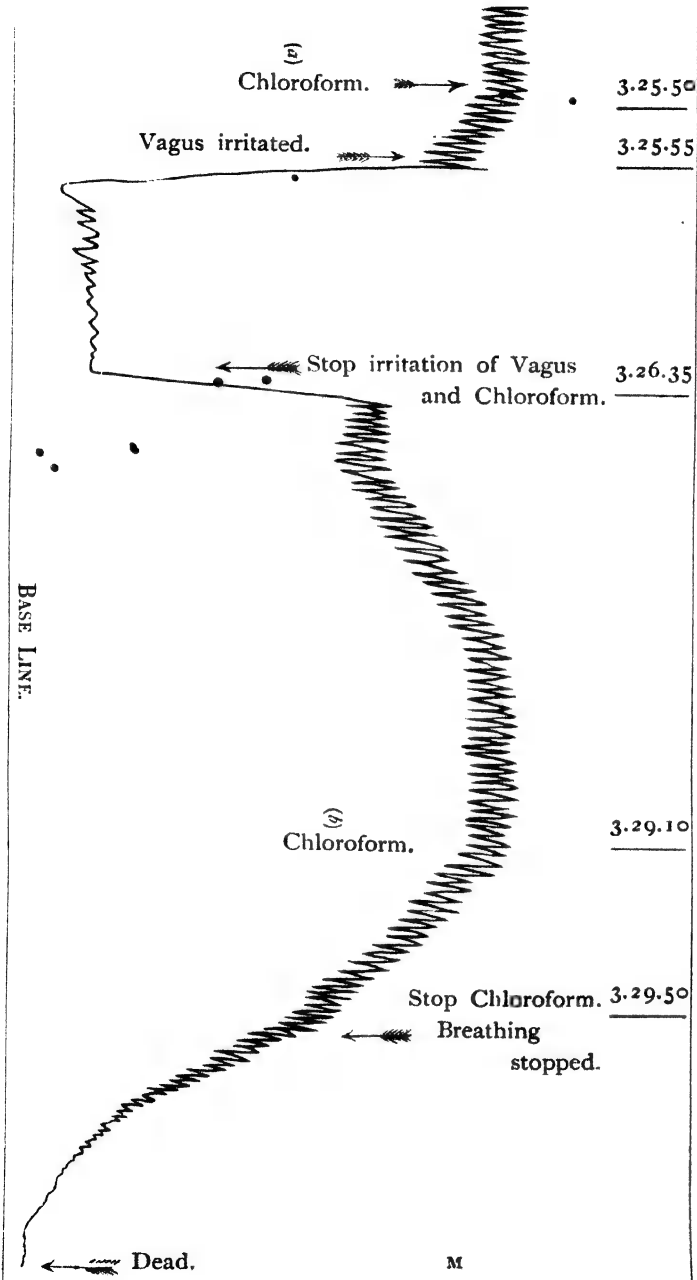
On the next day, May the 28th, 1890, the experiments were repeated with the manometer.

H. M. S.

- 3. 25. 50. Chloroform.
- 3. 25. 55. Irritation of the left vagus, acting well.
- 3. 26. 35. Chloroform and stimulation of the vagus stopped. No after-effect whatever.
- 3. 29. 10. Chloroform again.
- 3. 29. 50. Stop chloroform. Breathing feebly, but after a few weak respiratory movements the respiration ceased. Artificial respiration was kept up until
- 3. 34. 30. Rabbit dead.
- 3. 37. 0. Thorax opened. Heart seen beating feebly, flickers in the ventricle, slight beat in the auricle.

In both these observations chloroform was administered in the same manner for forty seconds. It

PROFESSOR RUTHERFORD'S EXPERIMENTS OF MAY 28TH, 1890, SHOWING THE EFFECTS OF
CHLOROFORM (a) WHEN THE VAGUS IS STIMULATED, AND (b) WHEN
THE STIMULATION OF THE VAGUS IS OMITTED.



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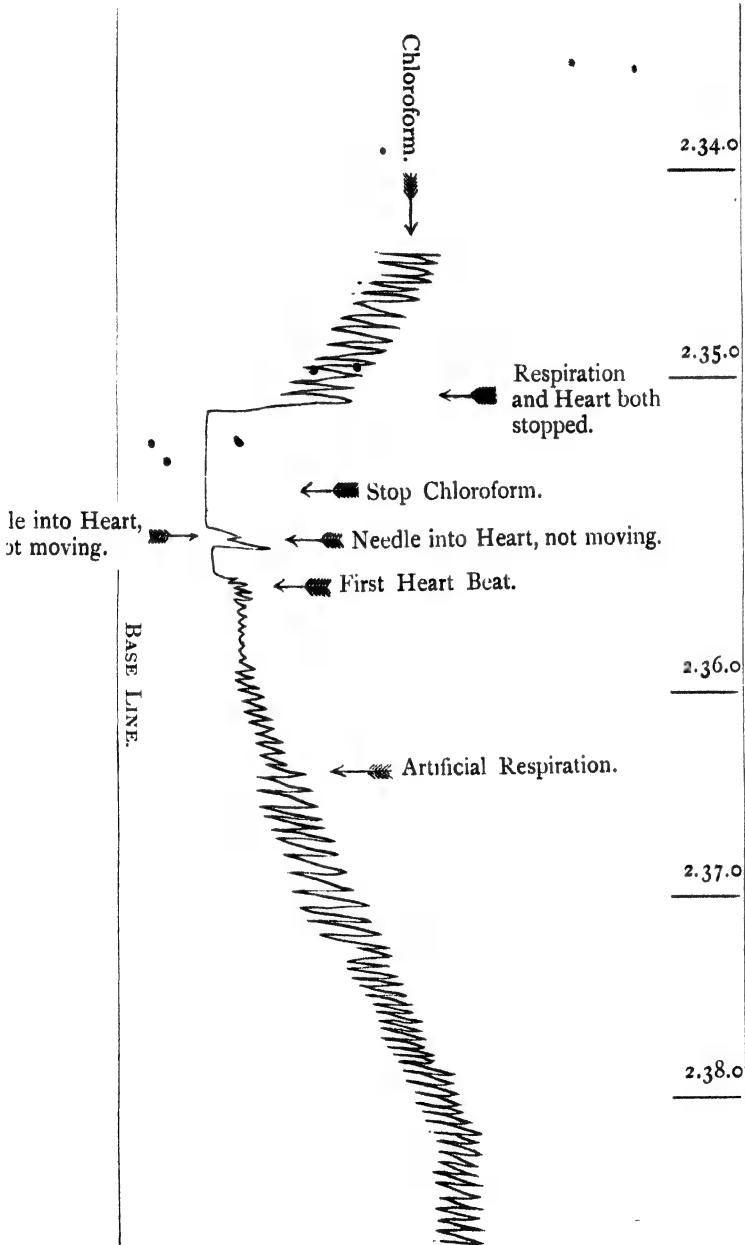
produced no effect while the vagus was stimulated and the heart's action arrested; without stimulation of the vagus it was fatal. The experiments of the Hyderabad Commission likewise prove that when overdosing occurs under chloroform the animal's life is not infrequently saved by stoppage of the heart through the automatic inhibitory action of the vagus, in precisely the same way as the lives of Professor Rutherford's rabbits were saved by stoppage of the heart through electrical stimulation of the nerve. The experiment which most distinctly illustrates the automatic action of the vagus, in producing stoppage of the heart when the animal was overdosed, is No. 178.

December 11th, 1899.—No. 178.

Dog put into chloroform box at 2 h. 1 m. 5 s. Fallen down at 2 h. 6 m. 30 s. Placed on the table at 2 h. 6 m. 55 s. and kept quiet with chloroform. Left carotid ligatured at 2 h. 13 m. 45 s. Canula inserted at 2 h. 14 m. 52 s. Connection with the manometer at about 2 h. 18 m. 30 s. Three Ludwig

and three Fick tracings. Chloroform was given four times gently until respiration ceased. On the first occasion a remarkable slowing of the heart was noticed just before and at the time the respiration stopped. Artificial respiration was commenced after about half a minute and natural respiration was soon restored. On the next occasion the heart completely stopped at the same time as the respiration. On the third occasion the heart again stopped at the same time as the respiration, and did not resume its beating for more than half a minute. After more than two minutes the animal made two feeble gasps. The pressure rose almost at once, and natural respiration soon returned. On the fourth occasion there was again marked slowing of the heart's action shortly after the respiration had stopped. Artificial respiration was begun after two minutes and a half and was successful in restoring the natural respiration. After recovery the chloroform was again pushed rapidly, and continued until death resulted without any attempt to restore the animal by artificial respiration. There was again some slowing and

EXPERIMENT No. 178 OF THE HYDERABAD COMMISSION, DECEMBER 11TH, 1889, SHOWING
 STOPPAGE OF THE HEART FROM AUTOMATIC ACTION OF THE VAGUS
 BROUGHT ABOUT BY OVERDOSING WITH CHLOROFORM.



intermittence of the heart's action, but the heart continued to beat for eight minutes after the cessation of the respiration. Only one observation and tracing are reproduced here.

H. M. S.

2. 29. 25.—Chloroform. At 2 h. 33 m. 0 s. the respiration became very irregular and ceased at 2 h. 34 m. 30 s. At the same moment the heart stopped completely. It recommenced to beat after some seconds, but there was a second and shorter arrest, recorded on the Ludwig tracing. Artificial respiration was employed at 2 h. 36 m. 30 s., but it was unnecessary as the animal would have recovered without it.

The following are the observations of the Hyderabad Commission regarding the effect produced on the action of chloroform by vagus stimulation—which can be brought about either by overdosing, or by holding the breath or asphyxia, or by experimental irritation of the nerve :—

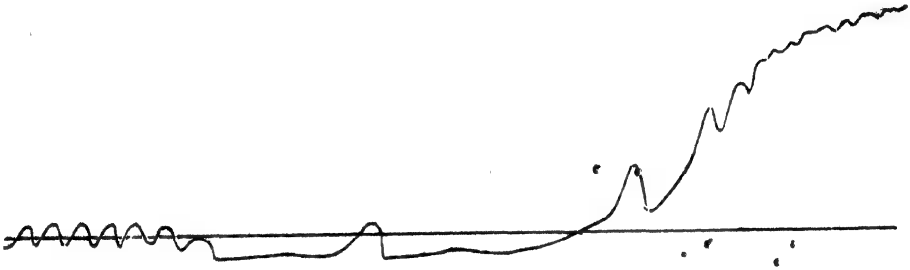
“(8.) The effect of involuntarily holding the breath, which, as anybody can prove by experiment upon himself, must happen when an inhaler saturated with chloroform is first applied to the face, is much more remarkable, the pressure often falling with great suddenness while the heart's action is markedly slowed. As soon as the animal draws breath again the pressure rises as suddenly as it fell, but the gasping respiration which succeeds then causes very rapid inhalation of chloroform with immediate insensibility and a rapid fall of blood pressure which quickly becomes dangerous.

“(12.) Complete, or almost complete, asphyxia, as by forcibly closing the nose and mouth or closing the tracheal tube after tracheotomy, has an effect similar to, but more marked than, that produced by holding the breath, and the character of the trace corresponds precisely to that produced by irritation of the peripheral end of the cut vagus. The pressure falls extremely rapidly, sometimes almost to zero, and the heart's action becomes excessively slow or

These Two Tracings read from right to left.

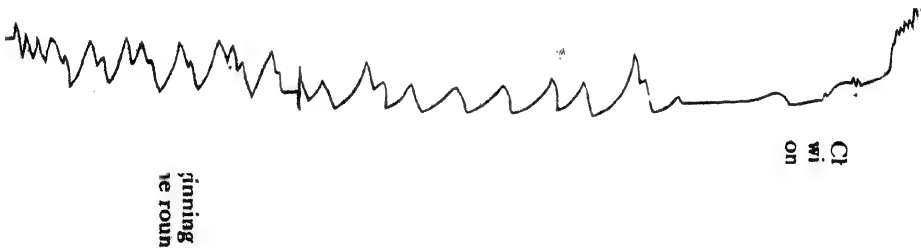
TRACE "A" OF THE GLASGOW COMMITTEE.

CHLOROFORM ADMINISTERED "BY A CLOTH SATURATED WITH THE AGENT BEING
HELD OVER THE MOUTH AND NOSE."



THE FICK TRACE OF EXPERIMENT No. 148 OF THE HYDERABAD
COMMISSION.

CHLOROFORM ADMINISTERED BY A CAP SATURATED WITH THE AGENT BEING
HELD OVER THE MOUTH AND NOSE.



These Tracings and Curves should be compared with those of Experiment
No. 186, where Chloroform was given with plenty of Air.

even stops for a few seconds. If the Fick trace of experiment No. 148 be compared with the photographic reproduction of trace A of the Glasgow Committee, it will be seen that they are identical, and that the slow action of the heart with great fall of pressure, which the Glasgow Committee attributed to some capricious action of chloroform upon the heart, was undoubtedly due to asphyxia.

“(15.) It only remains to be considered whether the slow action or temporary stoppage of the heart with great fall of pressure produced by vagus irritation is in itself an element of danger in chloroform administration, and if it is not, wherein the danger actually lies.

“(16.) The experiments in which deliberate irritation of the vagi was carried on during anæsthesia show unmistakably that irritation of these nerves diminishes rather than enhances the danger of anæsthetics. The effect upon the heart is never continuous, and as the vagus becomes exhausted, or when the irritation is taken off, the blood pressure

risers again, as it does when the same result is produced by asphyxia. The slowing of the heart and the circulation which is produced by irritation of the vagus by any cause, such as holding the breath in chloroform administration, retards the absorption and conveyance of chloroform to the nerve centres, just as holding the breath, whether voluntary or involuntary, prevents chloroform from entering the lungs, and of itself slowing or temporary stoppage of the heart in chloroform administration is not dangerous.

“(17.) To answer the second part of the last question in paragraph 15 is easy enough, if it is kept in mind that the effect of vagus irritation upon the heart is never continuous, and in chloroform administration, as the pressure rises again, after the slowing of the heart and temporary fall of pressure produced by any form of asphyxia, violent respiratory efforts with bounding heart's action lead, as in the case of struggling, to a rapid and dangerous inhalation of chloroform and consequent rapid and

dangerous decline in blood pressure. It is, in fact, the temporary exhaustion of the vagi after stimulation that is to be feared, and not the actual stimulation as long as it is continued.

“(18.) In accordance with this fact it will be found that in chloroform administration neither holding the breath—even if involuntary—nor vagus inhibition can be kept up beyond a certain time, and if the chloroform is not removed from the face one or both of two things may happen: (1) when the animal breathes again it takes deep and gasping inspirations, the lungs become filled with chloroform, and an overdose is taken in with extreme rapidity; or (2) when the restraining influence of the vagus is taken off the heart, through the irritation ceasing or the nerve becoming exhausted, the heart bounds on again, and the circulation is accelerated in proportion. The blood then becomes quickly saturated with chloroform, and an overdose is at once conveyed to the nerve centres. The theory which has hitherto been accepted is that the danger in chloroform

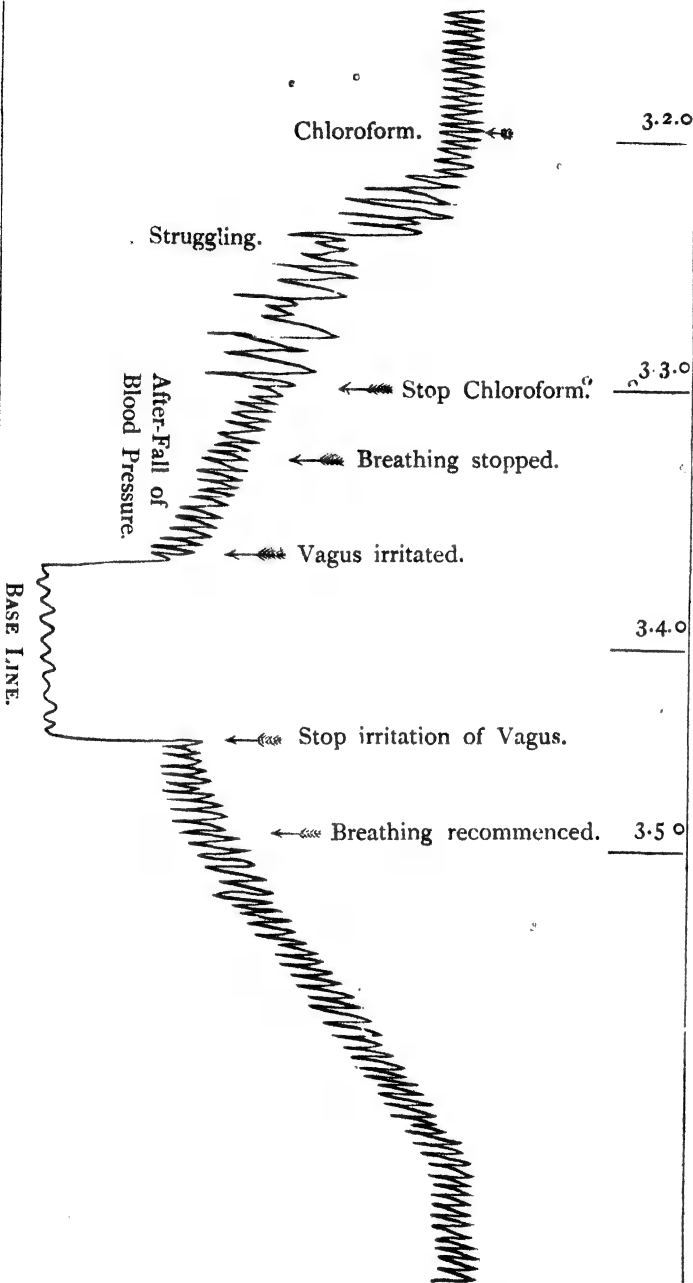
administration consists in the slowing or stoppage of the heart by •vagus inhibition. This is now shown to be absolutely incorrect. There is no doubt whatever that the controlling influence of the vagus on the heart is a safeguard, and that it is exhaustion of the nerve which is dangerous."

It is difficult to compare the experimental with the clinical data regarding the protective action of the vagus nerve in chloroform administration, since it is not called into play clinically unless the patient's breathing is interfered with, or he is overdosed. Two remarkable cases have come under the author's observation however, one experimental and the other clinical, which appear to illustrate the automatic action of the vagus nerve in warding off poisoning by chloroform, and are therefore worthy of record. The first happened during the enquiry of the Hyderabad Commission. A large healthy pariah dog was chloroformed until the breathing and the heart both stopped simultaneously. It was thought to be dead and was thrown out of the laboratory. While the next experi-

ment was being performed the late dog staggered back into the laboratory, having recovered spontaneously, and was soon quite well again. The clinical counterpart of the spontaneous recovery on the part of this dog occurred in the Afzulgunj Hospital on the 11th of November, 1891, and was reported in the *Lancet* in October, 1892. Chloroform was given to a male child aged $1\frac{1}{2}$ years for the extraction of a small calculus from the urethra. There was some difficulty in fixing the calculus, and the surgeon suddenly became aware that the patient's respiration had stopped. Attempts were made to restore the breathing, but without avail, and as there was no pulse and no heart sounds could be heard the child was thought to be dead. The surgeon had turned away and given the case up when the child was heard to gasp, and in a few minutes the breathing was restored and it was out of danger. Can there be any doubt that, as in this case, hundreds of the narrow escapes which have been recorded as having occurred accidentally during chloroform administration, would have proved fatal but for the safeguard action of the vagus nerve?

Experiments Nos. 76 and 159 of the Hyderabad Commission are very useful, as they demonstrate two phases of the after-fall of the blood pressure under chloroform. In every administration of chloroform there must be a residue of the anæsthetic in the system when the inhalation is stopped. This may be so small as to be practically inappreciable; or it may be harmless, because the vaso-motor stage of the blood pressure fall has not been passed, or because the respiration has been normal and regular throughout. But if there is struggling and abnormal respiration during the administration of chloroform, and an irregular intake, the residue may be so great that the after-fall may be prolonged, and it then becomes dangerous. In No. 76 there was an after-fall of the blood pressure produced by the inhalation of chloroform during the slight struggling and irregular breathing which is shown in the tracing. The after-fall was prolonged, but the animal, which was a strong healthy dog, was not fatally overdosed and recovered spontaneously after stimulation of the vagus. No. 159 shows the effect of chloroform in an animal weakened

EXPERIMENT No. 76 OF THE HYDERABAD COMMISSION, NOVEMBER 11TH, 1889,
 SHOWING A PROLONGED AFTER-FALL OF BLOOD PRESSURE,
 NOT FATAL.

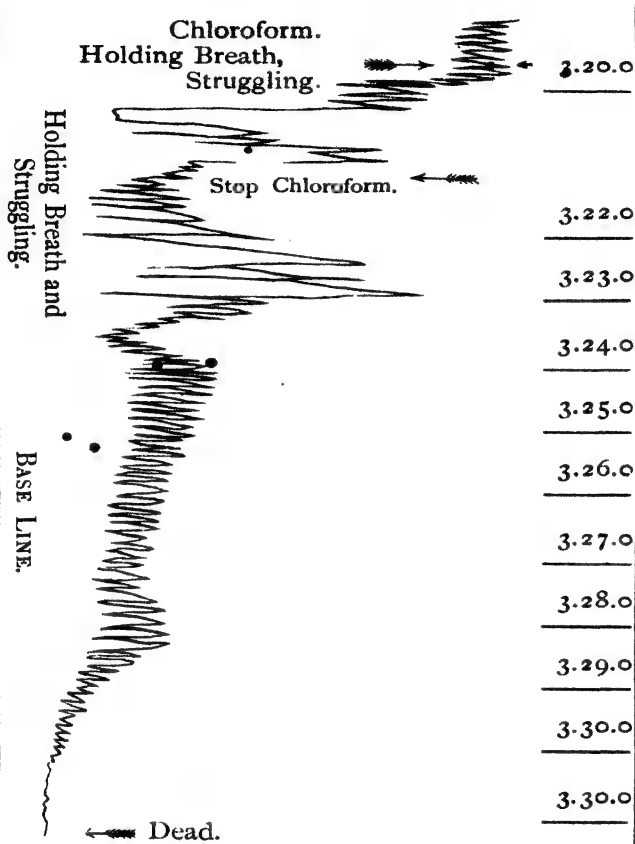


by phosphorus poisoning, while there was violent struggling and irregularity of the breathing. An overdose was taken in with fatal rapidity, and though the chloroform was stopped there was a prolonged after-fall of blood pressure, the respiratory centre was hopelessly narcotised, and before the narcosis had time to pass off the heart had stopped and the dog was dead. Briefly, in experiment No. 76 when chloroform was pushed with slight struggling and irregular breathing there was a severe after-fall of the blood pressure, but the animal recovered; in No. 159 the struggling and irregular respiration were violent and persistent, and there was an after-fall which was fatal.

November 11th, 1889.—No. 76.

Pariah dog. Weight 37 lbs. Temperature of the room 23.5° Cent. Into chloroform box at 2 h. 21 m. 36 s. Fallen down at 2 h. 28 m. 30 s. Placed on the table at 2 h. 30 m. 50 s., and kept quiet with chloroform. Artificial respiration at 2 h. 40 m. 25 s. and

EXPERIMENT No. 159 OF THE HYDERABAD COMMISSION, DECEMBER 4TH, 1889,
 SHOWING THE EFFECT PRODUCED ON THE ACTION OF CHLOROFORM
 BY HOLDING THE BREATH AND STRUGGLING.



into the artery at 3 h. 17 m. 10 s. Connection with manometer at 3 h. 19 m. 8 s. The animal was fully sensitive and chloroform was given almost immediately. Violent struggling with the breath held ensued, and afterwards deep inspirations and howling, during which he must have inhaled chloroform very freely. Chloroform was stopped after one minute and respiration ceased after about three-quarters of a minute more. Artificial respiration was at once commenced, and after about $3\frac{1}{2}$ minutes there were a few feeble gasping respiratory movements, which did not, however, raise the mean blood pressure at all. Artificial respiration was continued for five minutes longer, but failed to restore the animal, the heart ceasing to beat about ten minutes after the chloroform was commenced. The liver was distinctly fatty and the heart appeared to be soft and flabby. One Ludwig tracing only.

CONCLUSION.

THE introduction of the rule never to give chloroform while there is struggling and irregular breathing has already been followed by an appreciable improvement in clinical results. Formerly there was always an element of chance and consequently of risk in the administration, shown in the occasional cases of accidental overdosing which from time to time occurred: now overdosing never takes place.

TABLE SHOWING THE STATISTICS OF CHLOROFORM ADMINISTRATION IN THE AFZULGUNJ HOSPITAL DURING TWO PERIODS, (1) BEFORE AND (2) AFTER THE INTRODUCTION OF THE RULE ABOUT STRUGGLING.

(These Statistics should be compared with those in the Appendix.)

Period.	Total No. of operations performed under chloroform.	No. of cases of obstructed breathing under chloroform.	Restorative measures employed.		Percentage of cases of obstruction of the breathing.	Deaths.	Percentage of deaths.
			Pushing forward the lower jaw.	Artificial respiration.			
1. 1892 to March 20th, 1899.	14,174	302	284	18	2'1	1	0'007, or 1 in 14,174
2. March 21st, 1899, to October 10th, 1900.	3,126	2	2	0	0'06	0	0

From 1892 to March the 20th, 1899, there were 14,174 administrations of chloroform in the Afzulgunj Hospital, the head-quarters hospital at Hyderabad, of which complete notes were recorded in the manner described in Part IV. of this work. Of this number there were 302 cases in which the breathing became obstructed. In 18 of these cases artificial respiration was considered necessary, and in the remainder, where there was merely some embarrassment of the breathing, relief was at once afforded by pushing forward the lower jaw. During the decade 1890 to 1899, surgeons were coming more and more to consider it dangerous to push the inhalation of chloroform while the patient was breathing irregularly and struggling, but no rule had ever been laid down to guard with certainty against its evil effects. On the 20th of March, 1899,* a death from accidental overdosing occurred in the

* I was absent in Bombay, giving evidence before the Plague Commission, when the death from chloroform occurred in the Afzulgunj Hospital. A full report of the case was sent to the *Lancet*, but was never published.

Afzulgunj Hospital. Accurate notes had been kept throughout the administration by the House-Surgeon, and we were thus fortunately enabled to trace the accident to its true cause. The patient, who was a European, was very anæmic and had an enlarged spleen. During the inhalation he struggled long and violently, and just at the end of the struggling stage the cap was removed and air alone was given. After two breaths of air the cap was re-applied, but a dangerous after-fall of the blood-pressure must then have been going on. Almost immediately the cornea was found to be insensitive and the chloroform cap was again removed, but the breathing afterwards stopped, and although artificial respiration was commenced as soon as possible after the stoppage of the breathing was noticed, it was not successful. This disastrous case formed the turning point in the clinical history of chloroform. Up to the 20th of March, 1899, it had been left entirely to the discretion of the chloroformist to take away the cap or keep it on during the struggling stage, and there was no hard and fast rule to guide him

in so important a crisis. This serious defect was remedied by the immediate adoption of the absolute rule, which has ever since been implicitly acted upon, that—

“In every case where there is a struggling stage under chloroform, the cap must be removed, and it must not be re-applied until the chloroformist has satisfied himself beyond all possibility of doubt or mistake that no after-effect is being produced.”

The value of Dr. Bomford's discovery of the after-fall of the blood-pressure, on which this clinical law is founded, was in this way finally established. This fact is clearly demonstrated by our statistics, which show that whereas formerly the surgeon was obliged to resort to artificial respiration about twice a year, there has not been a single case of accidental overdosing—no case *i.e.* in which artificial respiration had to be performed—since the new rule came into force; and no words or figures can convey any idea of the comfort and freedom from

anxiety which it has brought to the chloroformist. The elimination of the element of risk in the administration of chloroform will not be without influence on that learned and powerful body, the anæsthesia specialists. The final removal of all dread of a direct, sudden, or capricious action of chloroform on the heart will vastly improve their position and usefulness, as it will increase the number of cases in which skilled anæsthetists will be called upon to administer it; and the full recognition of its paramount value in dentistry will widely extend their field of practice, as well as the advantages which the anæsthetic confers.

APPENDIX. •

MR. ROGER WILLIAMS' ANÆSTHESIA STATISTICS.

*Extract from the Report of the Hyderabad Chloroform
Commission, page 204.*

“My object in writing this letter is to point out that a perfectly reliable source of information is now available, so that in future there can be no excuse for ambiguity. For many years past there has been kept at St. Bartholomew's Hospital a most admirable record of the administration of anæsthetics and of the fatalities which have occurred. These have been published from year to year with the annual statistical reports of the hospital. Believing the subject well worth a little trouble, I have tabulated these records for the ten years 1878—1887. During this time chloroform was administered 12,368 times, with 10 deaths (1 in 1,236). During the same period ether was administered 14,581 times, with 3

deaths (1 in 4,860). In 9,072 of these cases ether was preceded by gas; 1 fatal case belongs to this category. In the other 5,509 cases ether alone was given, and two deaths occurred. These facts are very eloquent; they require no lengthy comment. I have long been aware of the greater safety of ether, and have therefore preferred it to chloroform in most cases, notwithstanding its disadvantages in some other respects. I believe this is the goal towards which professional opinion is steadily moving; and I think this movement likely to be most beneficial. Experience at other hospitals leads me to believe that the results obtained at St. Bartholomew's may be accepted as reliable averages. There can be no doubt, in these cases at least, that most of the fatalities occurred in spite of the greatest skill and care being used in the administration of the anæsthetic agents. Such being the case, it is impossible to arrive at any other conclusion than that such occurrences are unavoidable in a certain proportion of cases."

(Signed) W. ROGER WILLIAMS.

MR. ROGER WILLIAMS' STATISTICS.

(1878 to 1887.)

10 Years.

	No. of									
	Administrations.		Deaths.						Proportion.	
Chloroform...	12,368	...	10	...	or	1	in	1,236		
Ether	...	14,581	...	3	...	or	1	in	4,860	

DR. LAWRIE'S STATISTICS.

(1892 to 1900.)

8 $\frac{3}{4}$ Years.

Chloroform... 17,300 ... 1 ... or 1 in 17,300

These statistics afford striking evidence of the great superiority of Syme's method of giving chloroform over either chloroform or ether given in the methods from which Mr. Roger Williams' figures are taken. But they do not indicate anything like the full measure of that superiority. Syme's cases and my own form a continuous series of chloroform administrations extending over a period of fifty-three years—1847 to 1900. Syme never had a death

from chloroform, and the only fatality which occurred in the whole series is the one which took place in the Afzulgunj Hospital on the 20th of March, 1899. The death in this case was unquestionably due to an after-fall of the blood-pressure produced while the patient was struggling, and it appears certain that most of the deaths which Mr. Roger Williams holds to be "unavoidable," and were formerly attributed to direct cardiac failure—the old primary and secondary "chloroform syncope"—were due to this cause. Be this as it may, we now know how to guard against it by never allowing chloroform to be inhaled while there is struggling with irregularity of the respiration, and this rule applies equally to man and to the lower animals. In this way a dangerous or even a serious after-fall of the blood-pressure cannot occur, and the effects of the anæsthetic are always under the entire control of the chloroformist.

It is a curious circumstance that though so much has been written regarding the superior safety of ether to chloroform, no one has hitherto pointed

out the real and essential difference between the two anæsthetics. This difference was brought out in Mr. Victor Horsley's experiments on the effects of gunshot wounds of the brain on the respiratory centre, and consists in the fact that the after-fall of the blood-pressure which is produced by struggling and breath-holding under chloroform does not occur with ether.

